the trot, gallop, &c. The rise in the trot is sudden and simultaneous with the time the animal's feet are on the ground, and the fall with the time of suspension. In the gallop the same is the case, though the rises and falls are less sudden; they are, "therefore, less jarring to the rider, though they may, in fact, present a greater amplitude."

(*To be continued.*)

OUR BOOK SHELF

1.—*Les Roches; Descriptions de leurs Éléments: Methode de Détermination, etc.* Par Edouard Jannetaz, Docteur ès Sciences, etc. (Paris: J. Rothschild, 1874.)

2.—*Les Minéraux: Guide Pratique pour leur Détermination, etc.* Par F. de Kobell. Avant-propos et Additions, par F. Pisani, Professeur de Chimie et de Minéralogie. (Same publisher.)

3.—*Le Monde Microscopique des Eaux.* Par Jules Girard. (Same publisher.)

THESE three works form part of a series of popular scientific treatises issued by the enterprising Paris publisher, M. Rothschild. They are small volumes neatly printed and got up, and Nos. 1 and 3 are fully illustrated with well-executed cuts.

No. 1 is intended as a practical guide for the use of engineers, geologists, mineralogists, agriculturists, and pupils of Government schools. It is illustrated with thirty-nine woodcuts, contains a great deal of valuable information in small space, and seems well calculated to form a useful little handbook for the classes mentioned.

No. 2, which is a translation from the tenth German edition of Kobell's work by Count L. de la Tour-du-Pin, with a preface and additions by Prof. Pisani, is intended for the use of chemists, engineers, manufacturers, &c., and, like the above, seems well calculated to serve its purpose, of helping those who have a moderate knowledge of chemistry to analyse speedily and exactly the principal minerals.

No. 3 is of a much more popular kind than the two previously mentioned works; its author, M. Girard, is well known as a successful populariser of scientific results. It contains sixty-eight beautiful and useful cuts. It is intended as a handbook to those who wish to derive amusement and instruction from the use of the microscope, and takes up successively some of the principal points in the animal, vegetable (existing and fossil), and mineral kingdoms.

Nos. 1 and 2 have very full indexes appended.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

Periodicity of Auroras

ON my return to Newcastle-on-Tyne I take the opportunity of being able to recur to books of reference to reply to a question put by Mr. Procter, in NATURE (vol. x. p. 355), whether any complete catalogues of auroras have been constructed, and if they show indications of periodicity in its displays. Kæmtz's "Meteorology," in which almost every feature of the weather capable of being chronicled has been fully catalogued, probably contains a list more or less complete, up to its author's time, of all then known descriptions of auroras. If this be so, it has probably served for the groundwork upon which later and more complete catalogues have been compiled, extended, and completed in his own and other countries. Dr. Heis, the director of the Prussian Observatory at Münster, in Westphalia, is especially active in collecting information of the slightest appearances of aurora in any quarters of the globe, from whence published or private descriptions of them can be obtained. Every successive number of such works as Mr. G. J. Symons's *Monthly Meteorological Magazine* and the *Quarterly Journal of the Scottish Meteorological Society* contains, in a few pages of "meteorological notes" on the weather peculiarities of each month from their numerous observers, a list of scattered aurora-observations, which is probably as complete for the British Isles during the years in which these publications have been carried on, as the perfect or partial clearness of the sky over this country, and indeed over some adjacent continental stations, enables such a list to be made by observations. But this collection, invaluable as it is for our own immediate field of registry, is not assorted, nor suited, without extension by the help of similar collections made in surrounding foreign countries, to be regarded as a sufficiently extensive list of auroras for dealing generally with the question of their periodicity. The present state of progress of our knowledge, with regard to auroral frequency, we owe largely, if not almost entirely, to the researches of Prof. E. Loomis, of Yale College, U.S., the results of whose discussion of the collateral views and considerations involved in them will be found in numbers of the *American Journal of Science* for July 1860, Sept. 1870, and April 1873. In the first of these papers, a map of lines of equal auroral frequency for the northern hemisphere is presented, dividing the northern area of the globe into zones encircling the arctic regions. It appears, for example, from this map, that auroral displays are not very much more frequently visible in St. Petersburg than they are in London, and that even Boston and Edinburgh are as frequently visited by them as the great northern capital itself. An oval belt of greatest auroral frequency encloses together the north geographical and north magnetic poles, covering all the European, Asiatic, and American coast lines of the Arctic Ocean, and passing onwards from the latter across Hudson's Bay, the mouth of Baffin's Bay, and Iceland, back to the North Cape. For a short distance within this ample belt auroras continue to be tolerably frequent, and grow comparatively more scarce in Smith's Sound and the northern parts of Baffin's Bay, and indeed apparently in proportion as the geographical north polar regions are approached.* It is with the outer and not with the inner margin, however, of this ring-maximum of auroras that observers in ordinary latitudes are concerned, and it is pointed out in his most recent paper by Prof. Loomis, that in constructing general catalogues for deciding questions of auroral periodicity, a line, or at least a restricted zone, bordered northwards and southwards by lines of equal auroral frequency, should be chosen as the localities from which observations may be gathered. To place this line or belt in the zone itself of almost constant auroral activity, where auroras can only vary periodically in brightness rather than in

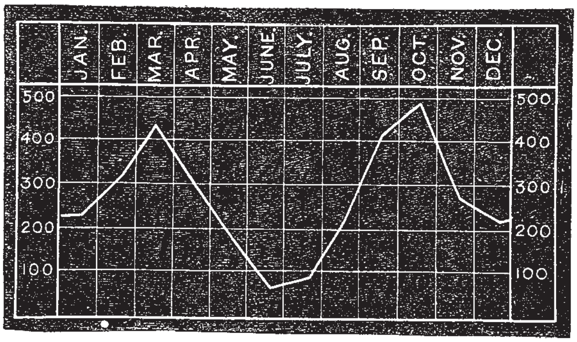

FIG. 1.—Number of auroras observed in each month of the year (Kæmtz).

---

* It will be remembered that in Capt. Kane's description of a winter-detention of his vessel in Smith's Sound (the northernmost passage from Baffin's Bay, about eight and-a-half degrees from the north pole), it is related that the feeling of prolonged darkness at length became so oppressive that even the Esquimaux dogs were affected by it, and when excluded from the luxury whined piteously for light. A darkness so deep and enduring as this description suggests can scarcely have been broken, as it occurs in the more favoured belt twenty degrees south of this high latitude, at the mouth of Davis Strait, by the illumination of bright rays and flashing beams of constantly appearing fine auroras. The position occupied by Capt. Kane was not more than two or three degrees from the general centre of the region of fast-diminishing auroral frequency, embracing the whole Arctic Ocean, which is shown on Prof. Loomis's auroral map as merging insensibly on all sides into the broad or narrow belt of greatest auroral activity surrounding it. The latter seems to follow very nearly along its whole extent, with a corresponding strong depression and expansion of its width towards Hudson's Bay, the general direction of the arctic coast-line.

frequency, would be of no avail for enumerations; the zone selected must be one of occasional auroras, arising only from the southward spreading of the strongest disturbances of the ever-beaming and sometimes forth-sallying illuminations of the north.

It is also for such other obvious reasons, as that years of arctic exploration tend to appear in general catalogues as years of extraordinary auroral frequency, and that observations in Asia, Western America, and in the whole of the southern hemisphere have for the most part been made but recently or at very irregular intervals, that the use of general auroral catalogues in questions of periodicity calls for much selection and reduction of the miscellaneous mass of observations. A most extensive general auroral catalogue appears to have been published early last year, or at the end of the previous year,* by Prof. Lovering, of the United States, of which Prof. Loomis has employed the materials, and of which he acknowledges the completeness in terms of commendation. It extends from the year 500 B.C. to the year 1864, and includes with its supplements upwards of 12,000 cases of observed auroras. For the following years, from 1864 to the end of 1872, Prof. Loomis has continued the catalogue for a restricted area suited to the question of periodicity, partly from American sources, and partly (in Europe) from the periodical journal published by Dr. Heis, *Wochenschrift für Astronomie und Meteorologie.* The selected region of observation is limited on the north by an iso-auroral line skirting the northern boundary of the State of Massachusetts and crossing the Atlantic from near Boston to the north of Ireland, passing thence between England and Scotland, and through the northern part of Jutland, a little south of Stockholm, to a little north of St. Petersburg, where it continues its course in Russia as far as long. 40° E. from Greenwich. The meridian of this longitude (nearly that of the eastern ends of the Black Sea and Red Sea) limits the area on the east. It is similarly limited westwards by the meridian of 80° W. from Greenwich, including Washington, and the eastern, but none of the western States of North America. A lengthy general catalogue for this region was extracted by Prof. Loomis from Lovering's list, including all the auroras recorded in it in the years between the beginning of the year 1776 and the end of the year 1872, with their month and dates. The whole of this long list, supplemented in great measure by his own inquiries, is given at full length at the end of the last paper (*sup. cit.*) by Prof. Loomis. The number of auroras in each year, or their annual frequency, is then obtained and laid down in a curve for the whole interval of ninety-six years of the observations. On the same plate is projected the mean daily range of magnetic declination, and the relative extent of black spots on the sun's disc for the same series of years of observation; the latter from Wolff's numbers, and the former from the average of magnetic observations made at Prague from the year 1777 to the year 1871 inclusive. Very uncouth in appearance are all these curves: and the curve of annual auroral frequency is far the most shapeless in outline of them all; but the leading crests and troughs of the ruling eleven-year period of the sun-spot curve are conspicuously reproduced in each of the other two curves, so that it is difficult to say whether the auroral curve or the curve of magnetic declination is the stricter in its adherence to the times of maxima prescribed to it by the solar spots. In two cases, however, the auroral maximum took place some three years, and in another case about a year, too late (1840, 1851, 1871). The maximum of the magnetic disturbance curve also took place on one of these occasions (1838) a year later than the sun-spot maximum, while in the year 1787 both the auroral frequency and magnetic disturbance curves attained their maxima together between one and two years earlier than the sun-spot curve.

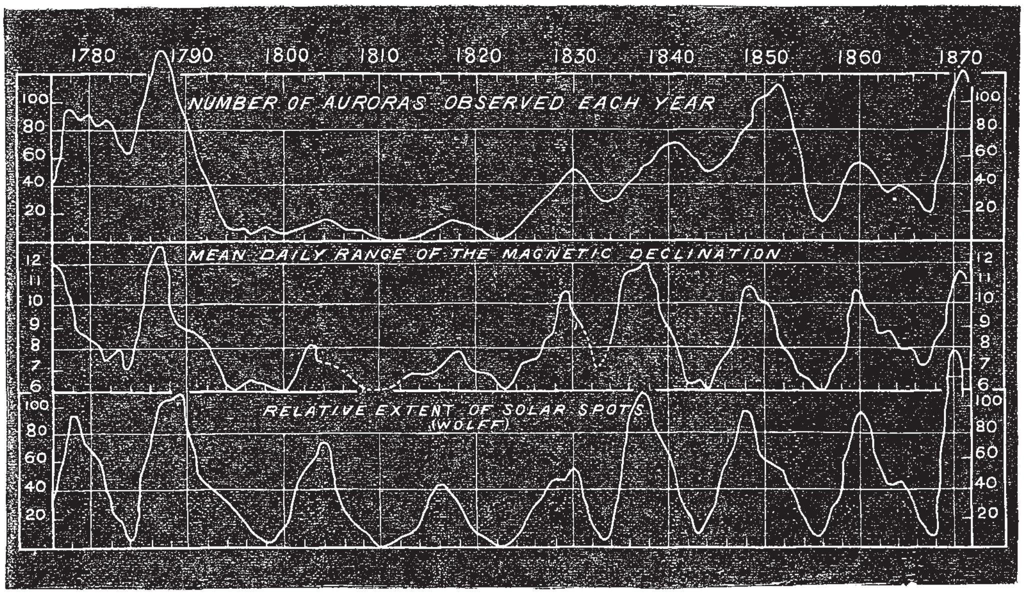

FIG. 2

Prof. Loomis concludes that the times of auroral minimum and maximum frequency happen on an average from half a year to a year later than the same critical times of magnetic disturbance and of the sun's relative obscuration by black spots; that they are more nearly related to the same times for the magnetic daily range than for the sun-spot curve, and that the time of greatest auroral frequency lasts longer than that of the sun's obscuration by spots or of the magnetic needle's greatest daily disturbances. A period of very moderate activity in all the curves is embraced between the maxima of 1788 and 1830, which is particularly noticeable in the scarcity of auroras and in the smallness of the magnetic oscillations in that period. More than 4,000 auroras are included even in the limited selection from Prof. Lovering's catalogue used by Prof. Loomis to establish these results, and yet the interval of ninety-six years (during which the magnetic declination had been continuously observed) to which it is confined proves to be too short to determine certainly the long cycle of activity and repose that seems to govern the times of greatest auroral frequency for years together, in long recurring periods of between half a century and a century. In a previous paper (the second in the *American Journal of Science* above quoted), Prof. Loomis had arrived at all the conclusions of the paper just described from an auroral catalogue of his own construction, of observations in not very northerly latitudes of Europe and in the United States; extending, however, only to the year 1850, the closing year of the magnetical observations at Prague then accessible to him. A period of about sixty years, from the maximum of the year 1790 to that of 1850, was thence concluded, perhaps too confidently, as the real length of this long cycle of auroral frequency.

---

* "Memoirs of the American Academy," vol. x.

On turning to Kæmtz's "Meteorology" (translation by C. V. Walker, 1848, p. 458), I find that the author, with his usual exhaustive completeness, has constructed a general list of auroras observed up to his time (about the year 1820), and has established from it certain laws of their periodicity. The list itself, although not given for brevity in the translation, is in all probability contained in the original, and it must embrace upwards of 3,000 cases of auroral occurrences, since a table of about that total sum showing the numbers recorded in each of the several months of the year is given as the most important scientific result of the compilation. The numbers seen in March, September, and October are about half as great again as those recorded in any of the adjacent months, and about twice as great as have been recorded in either of the two mid-winter months of December and January, when the length of the nights is yet most favourable for their registry. That the numbers of auroral displays noted in June and July are relatively very small is easily explained by the length of the twilight in those months in European latitudes, rendering many, that would be conspicuous exhibitions in darker nights, invisible.

The times of greatest annual activity of the auroræ are thus about the seasons of the equinoxes, when the seat of the most direct action of the sun's rays upon the earth's surface is undergoing its most rapid changes during the sun's yearly course; and when nearly the same parts of the earth's surface continue to be heated directly by the sun's rays at the seasons of the winter and summer solstices, there are times of comparative repose and tranquillity among the exhibitions of auroral outbreaks.

Regarding a secular period, Kæmtz's Catalogue appears to have shown nothing positive. "A period of this kind," he writes, "occurred between the years 1707 and 1790, attaining its maximum about the year 1752; since the year 1820 they have again continued to become more numerous." This maximum in the year 1752, and those shown on Prof. Loomis' auroral curve about the years 1780-90, 1850, and 1870-72, agree very ill with each other, or with the return of a constant cycle of long period connecting them together; the succession more nearly resembles that of periods of hot summers, or of cold winters, governed by fixed laws that have not yet been discovered in their returns and durations: and seems to point to causes influencing the production of auroras very similar to those which determine some of the obscurest features of our seasons. Thus, since the commencement of the earliest continuous temperature-records at the Royal Observatory, Greenwich, in the year 1771, the commencement of winter or the arrival of a mean daily temperature of 40° has fluctuated between the months of November and December, apparently from different degrees of prevalence in those months of an annual tide of south-west wind then reaching a maximum in the British Isles. Assuming changes in the strength of this wind to be the cause of the observed fluctuations and of a gradually increasing retardation of winter and secular rise of mean temperature in the months of November, December, and January, noticed by Mr. Glaisher during the first half of the present century, the average course of this phenomenon, when submitted to examination, resembles very closely the general course of the curve of auroral frequency. There was a sensible retardation of the winter season from about the year 1775 to about the year 1790, followed by a marked acceleration from the latter year onwards through nearly the first quarter of the present century, indicating apparently a considerable abatement of south-west, anti-trade, or equatorial currents, on an average, for that lengthened period. The acting cause however returned, and its strength may be gathered from the fact that the mean temperature of the month of December at Greenwich during the twenty-five years from 1825 to 1850 was higher in eight years than that of the month of November, an anomaly which had only taken place thrice in the first quarter of the century. The last occurrences of the same kind, with which I am acquainted, happened in the years 1858, 1861, and 1862; but the strong retardations of winter, noticeable towards the year 1850, were then rapidly disappearing, and it is not improbable that in the further fluctuations that have since followed, a new correspondence between the secular rise of temperature of the months of November, December, and January at Greenwich, and the considerable maximum of auroral intensity reached during the years 1870-1873, may be found to bear out an analogy which is only hazarded here, in the absence of a better working hypothesis, as an apparently real and perhaps not altogether unnatural connection.

With regard to the relative proportion between eastward and westward movements of auroral rays, I know of no observations that have been made that can offer Mr. Procter any additional information. The possibility that auroral streamers may be uprushes of positive or negative electricity to a point of saturation in the highest regions of the atmosphere, followed by downrushes of the same electricity when the exciting cause in the interior or on the surface of the globe subsides, might be well proved by such observations. The existence of the motion shows that the auroral rays diverge sensibly from the earth's lines of magnetic force, probably in the endeavour (whether effectual or not is indifferent to the explanation) of the Aurora Borealis and Aurora Australis to combine and to neutralise each other (perhaps a rare occurrence) across the equator. The strength of the motion of the beams may be some measure of this tendency, and its absence a sign that the aurora is local and of comparatively little generality and extent. It may here be remarked that the annual periodicity of auroras differs entirely from that observed in the average frequency of sporadic shooting stars, which reaches a maximum in August and September, but has a well-marked minimum in March, resembling the single cold of winter and the single heat of summer produced three months earlier, in each year, by the tropical motion of the sun. A marked frequency of auroras on the dates of January 1-3, April 19-21, August 9-11, October 18-21, November 14 and 27, and December 10-12, when meteor-showers of various degrees of brightness are of almost annual occurrence, has not, as far as I am aware, been definitely traced and established; but the large auroral catalogues recently published by Prof. Loomis and Prof. Lovering will, it is evident, supply very valuable materials by which any such connection between auroras and periodical meteor-showers, if it exists, can be more thoroughly investigated and determined.

A. S. HERSCHEL

Automatism of Animals

YOUR correspondent, Mr. Wetterhan, has, I think, misunderstood Prof. Huxley's argument; which is, not that the adjusted motions he refers to never were the result of conscious and voluntary motion, but that they are not so now. His letter has, however, induced me to call attention to what has always seemed to me a real difficulty. As I understand automatic or reflex actions, they are those which have been so constantly repeated and which are so essential to the well-being of the individual, that the various nerves implicated have become so perfectly co-ordinated that the appropriate stimulus sets the whole machinery in motion without any conscious or voluntary action on the part of the individual. Thus we can quite understand how a paralysed limb would be drawn up when the sole of the foot is tickled or the toe pricked. If, however, any such irritation continues to be felt in the normal state, a man would stoop down and remove the irritating substance with his hand, or would place his foot upon the opposite knee, and, stooping down, endeavour to *see* the object which caused the irritation. But these are *conscious*, not *reflex*, acts. They are not repeated often enough, and are not sufficiently identical in form, to become automatic; and we are not told that a wholly paralysed human body does actually go through these various motions, as it certainly would do if not paralysed.

Now, in the case of the frog I can quite understand the jumping, swallowing, swimming, and even the balancing; for all these are actions so essential to the animal's existence, and so often repeated during life, as to have become automatic. So, also, I can understand the drawing up of the foot to remove an irritation on the side of the body, for with the short-necked frog this too is an essential, and must have been an oft-repeated action. But we are further told that "if you hold down the limb so that the frog cannot use it, he will, by and by, take the limb of the other side and turn it across the body, and use it for the same rubbing process." Now, this seems to me not to be explicable by automatic or reflex action, because it cannot have been an action frequently if ever performed during the life of every frog. It is true that from the co-ordination of the movements of the opposite limbs, we might expect, if the irritation were continued, and the leg on the same side kept for some time in motion, that the other leg would begin to move *in the same way*. But what causes it to move in a quite different and unusual way, *across* the body to the opposite side; and this, as related, at once and without first trying its own side? The most usual motion of both legs is directly up and down, each on its own side. What is it that causes one of these legs, when it